Testing of the IMRA Wattlite Laser

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Testing of the IMRA Wattlite laser

Long term testing of the IMRA Wattlite oscillator began this month. The oscillator was operated for over 250 hours while monitoring the output power, the center wavelength and the pointing stability. Due to safety requirements, data was only collected during normal working hours. At night, the external (LLNL) shutter was closed so no data was collected, however, the laser continued to operate. In this mode of operation, approximately 80 hours of data was taken during the 250 hours of operation. The laser was turned off during the two weekend periods of this test series and restarted the following Monday. The warm-up period of the oscillator is most evident in the wavelength data shown in Figure 1. During the two cold start periods, the laser required about two hours for the wavelength to stabilize. Excluding the warm-up periods, the wavelength drift was approximately ±0.1nm over the 250 hours of operation.

The output power was monitored with a large area photo-diode. A plot of the output power as a function of time is shown in Figure 2. The two cold start periods are also evident in this data showing the same two-hour warm-up period for the power to stabilize. Once the laser was stable, the output power varied by only a few percent. It is also important to note that there is no degradation in the output power over the 250 hours of operation.

The pointing error from the oscillator was monitored by focusing the output beam onto a video camera. The data acquisition program finds the centroid of the focused spot to the nearest pixel on the CCD array. The resolution of the system was 42 micro-radians/pixel in the horizontal axis and 49 micro-radians/pixel in the vertical axis. A plot of the pointing error as a function of time is shown in Figures 3 and 4. The pointing errors recorded are very small and are near the resolution of the diagnostic system. This is not surprising considering the output beam is from a single mode fiber. The pointing stability should only be related to how rigidly the output end of the fiber is mounted. Another advantage of the fiber output is that the pointing does not change as the laser warms up from a cold start.

Although a warm-up period is required for the IMRA oscillator, the long term stability in power, wavelength and pointing appear to be sufficient for the prototype laser system.
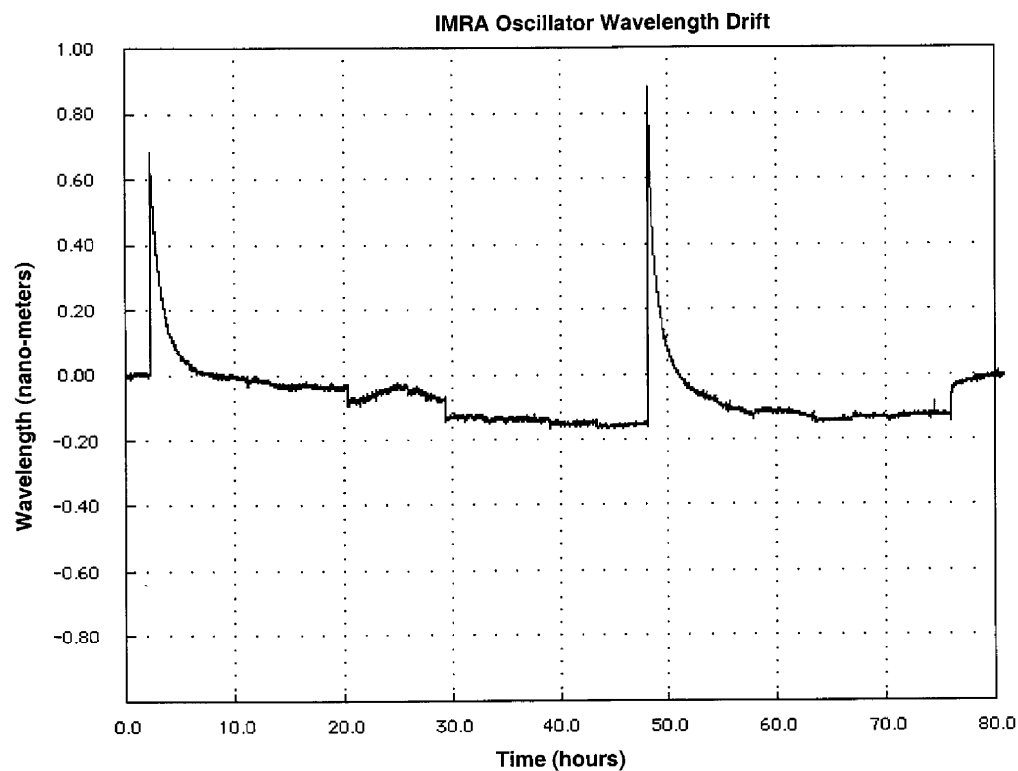
IMRA Oscillator Wavelength Drift

Figure 1. Wavelength drift in the IMRA oscillator as a function of time. The two large spikes are caused by the oscillator warming up from a cold start.
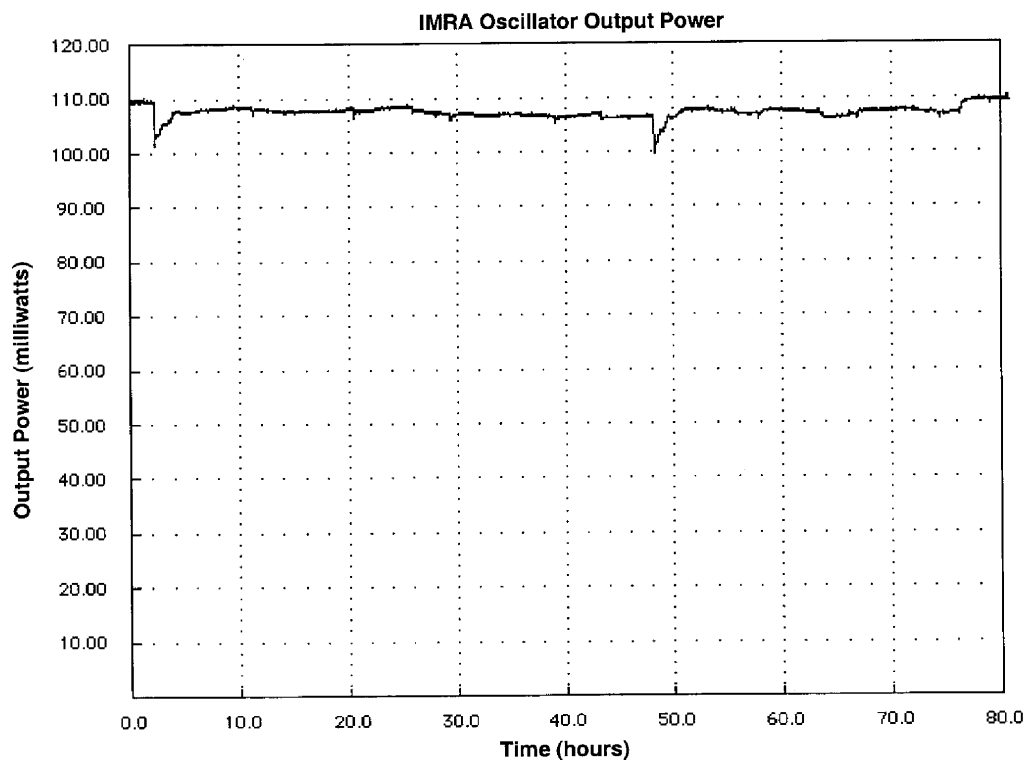
IMRA Oscillator Output Power

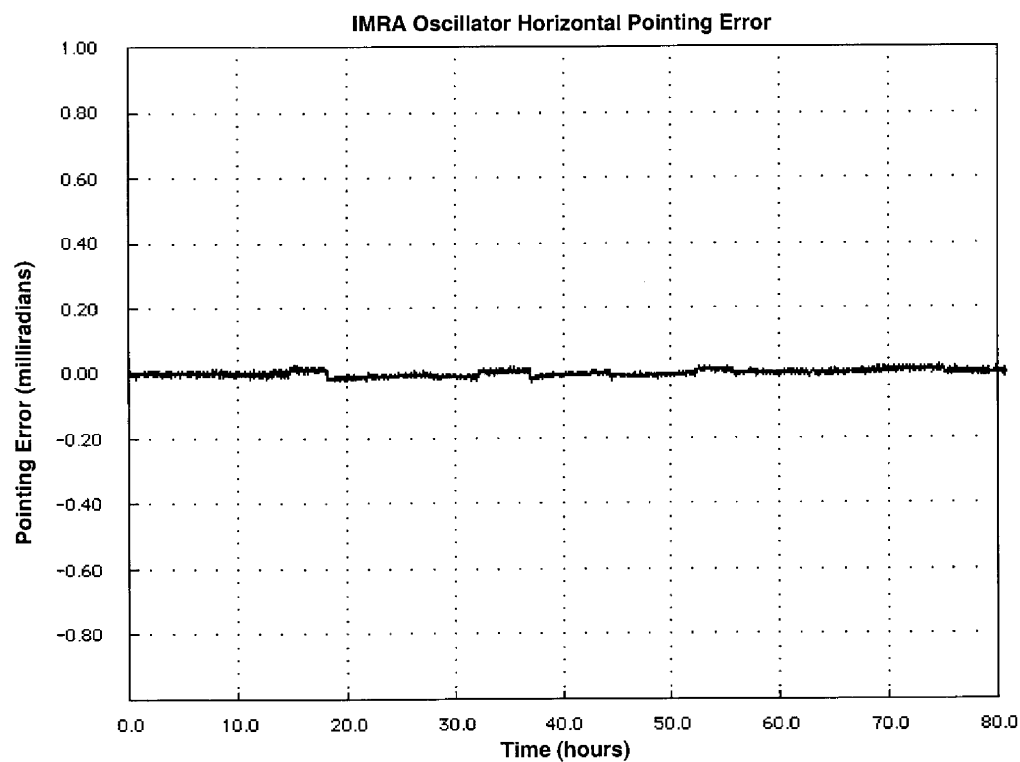**Figure 2.** Output power of the IMRA oscillator as a function of time.

Figure 3. IMRA oscillator horizontal pointing error as a function of time.
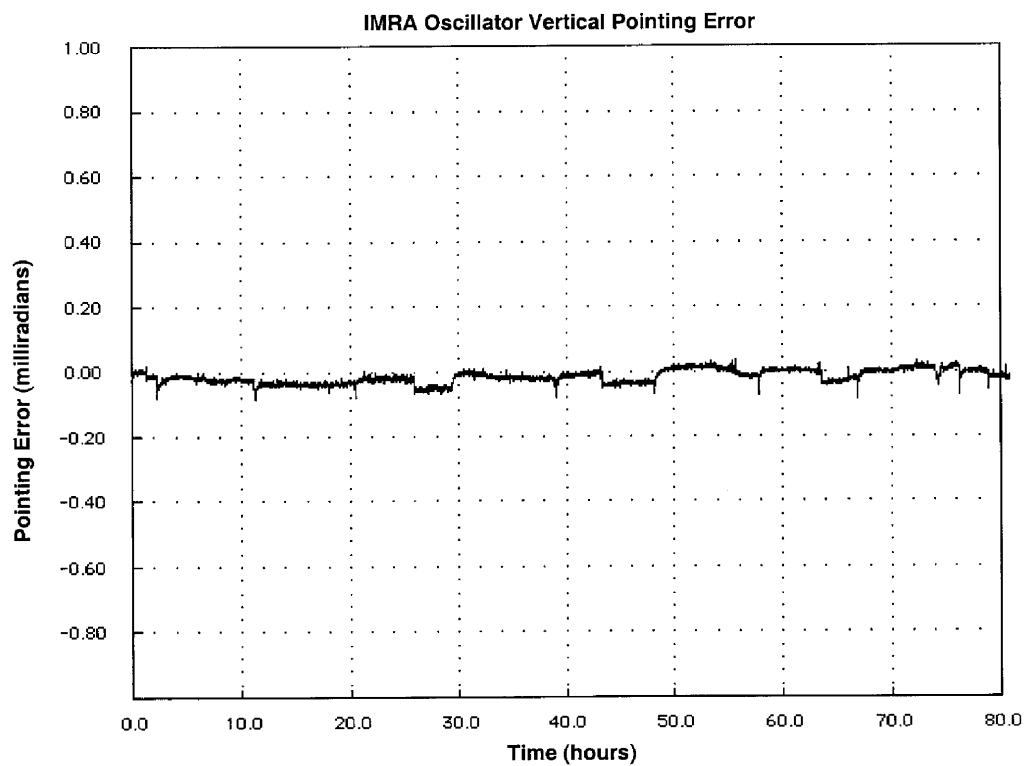

Figure 4. IMRA oscillator vertical pointing error as a function of time.

IMRA oscillator pulse compressibility

The final remaining issue with the IMRA oscillator is the compressibility of the output pulses. The phase of the pulse, $\phi(\omega)$ can be represented by a Taylor expansion about the central frequency, ω_0:

$$\phi(\omega) = \phi_0 + \phi_1(\omega - \omega_0) + \phi_2(\omega - \omega_0)^2 + \phi_3(\omega - \omega_0)^3 + \phi_4(\omega - \omega_0)^4 + \ldots$$

In order for the amplified pulse to be transform limited (meaning the shortest pulsewidth for the given bandwidth), the frequency dependent phase of the pulse must be zero or negligible. This simply means the higher order terms, ϕ_n (for $n \geq 2$), must be negligible. As expected, the pulses from the IMRA oscillator does contain higher order phase terms, and thus not transform limited. Depending on the magnitude and sign, the higher order phase terms can be corrected for by using the stretcher/compressor. Therefore, the remaining task is to compress the pulses from the IMRA oscillator to transform limit. The pulses directly from the IMRA oscillator were measured to be 8 ps (Figure 5). The measurements done by ALD agreed with measurements performed at IMRA. Based on the measured output spectrum, the transform-limited pulses should be 425 fs FWHM.

Using a compressor (1200 lines/mm gratings) provided by IMRA, the pulses were compressed to 1.3 times transform limit. By clipping the bandwidth down to 2-nm FWHM in the compressor, pulses 1.1 times transform limit were obtained. These results were also comparable to those measured at IMRA.

Currently available optics were used to construct a stretcher and compressor similar to the actual design (larger optics will be used in the actual design). The output bandwidth from the compressor was limited to 0.8 nm FWHM due to the size of the available optics. Based on this spectrum the transform-limited pulses should be 2.7 ps FWHM. The shortest pulses that we were able to obtain after stretching and compressing was a factor of 1.1 greater than the transform limit (see Figure 6).
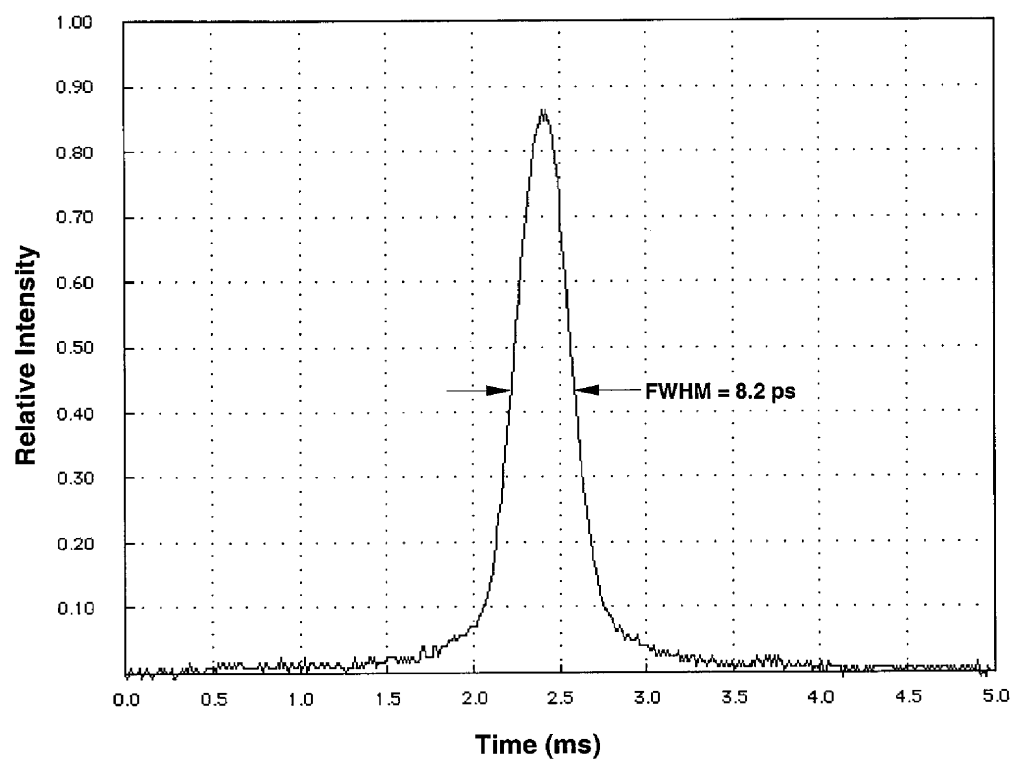
Figure 5. Auto-correlation trace showing output pulsewidth of IMRA oscillator. 8.2 ps is the pulse intensity FWHM assuming a gaussian pulse.
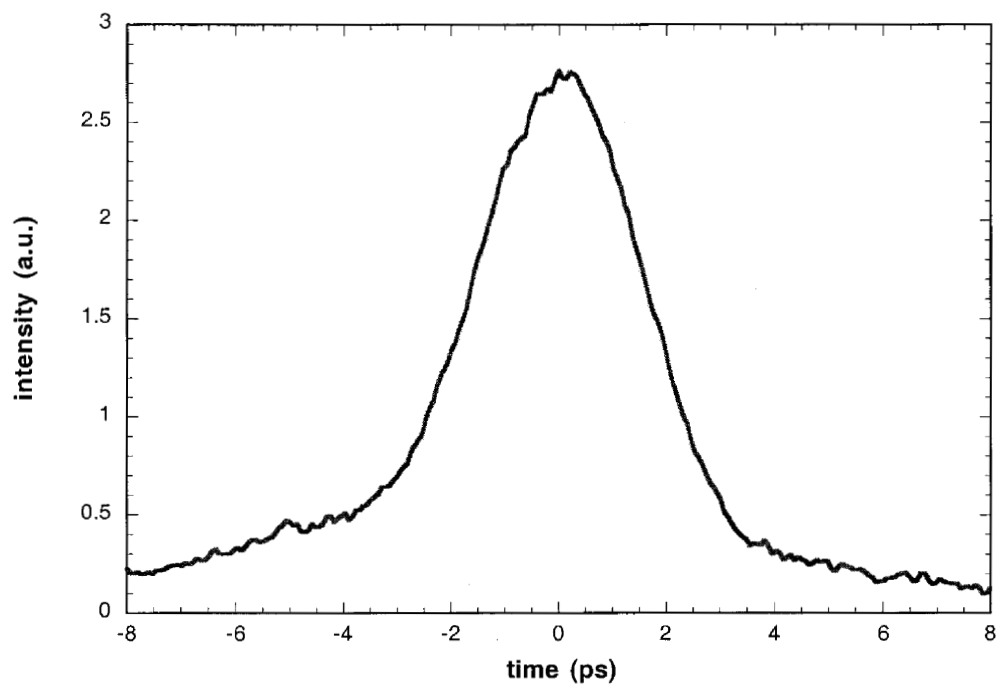
Figure 6. Auto-correlation (3.9 ps FWHM) after stretching and compressing. Corresponds to a 3-ps FWHM for the pulse intensity (factor 1.3 was calculated using measured spectrum, 0.8 nm FWHM).